EQUIPMENT FOR ECOLOGICAL GRAIN DRYING WITH MICROCLIMATE MONITORING AND DISTANCE CONTROL

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Abstract. Preliminary results are reported about an environmentally friendly small/medium capacity grain storage facility on a farm. During the operation of the self-made ecological barn, which has a grain storage–drying facility, it was equipped with computerized monitoring of moisture, temperature and the air flow intensity. Five sensor arrays were located in three different places of the storage-drying facility to control the flow of air over the grain, one of them to control the inflow of air, and another one to control the condition of air outside the barn. Special equipment was made for preheating air by means of the sun and/or by firewood burned in the furnace to ensure the desirable temperature and moisture. The results obtained show that fast and direct information about the temperature and humidity in the grain storage facility and outside is very useful to the farmer. "Soft" drying of grain in a small facility of the farm can be achieved using only natural resources – the heat from the sun and firewood. Active ventilation is preferred to ensure the necessary air flow through the grain. Online monitoring of moisture and temperature in the grain storage facility prolongs the time of drying by means of active ventilation. The drying period was extended by 15-25 % every day owing to the information obtained from the digital temperature and humidity sensors. The use of computerised ventilated bins for drying and storing grain is purposeful in the organisational, as well as economical and ecological aspects. It facilitates the farmer to organise the harvesting process, to use favourable weather conditions to a full extent, to obtain a higher-quality product and sell it on more profitable terms. This increases the manoeuvrability of production, makes it less dependent on the weather conditions and the grain reception centres and raises the profitability of grain production. For example, on the farm "Mazkalnini" the income from selling conditioned wheat in the years 2007 and 2008 was twice higher than that from the sales of grain directly from the harvester.

Key words: grain drying, grain storage, ventilated bins, using solar energy, computerised monitoring of the drying process.

Introduction

In the Baltic States with their humid and unstable weather conditions, the production of high-quality food and forage grain harvested by means of combine harvesters and suitable for continual storage requires careful treatment after harvest: removing admixtures, drying, sorting, i.e., conditioning and proper storage. On small and medium-size farms ventilated bins that combine grain drying and storage functions are most appropriate. They are of more universal character and do not need high investments for their erection. Solar heat, accumulated by means of a film collector, is used to warm up the air but a generator of heat (a firewood burning furnace) is provided as a reserve source of heat [1]. The weak point of these drying systems is that they do not have a control implement of the drying process, which causes insufficient or too great desiccation, lowering of the quality of grain, uneconomical utilisation of the days suitable for d~~r~~aying, and overconsumption of energy.

The aim of the investigation is to ensure uninterrupted control (monitoring) of the grain drying and storage process.

Materials and methods

A computer system with sensors DS1923 (firm «Dallas Semiconductor») has been worked out to control the technological parameters (temperature and humidity) of the grain draying process (see in this issue the article V. C. Ogorodniks & others: "Automated control of the grain drying process"). In order to carry out investigations using this system, it was set up on ventilated grain drying-storage bins arranged in a barn of the "Mazkalnini" farm, Tervete Region (Latvia). In this embodiment there are five sensors used: three sensors (S-1, S-2, S-3) are located in the ventilated bins (one sensor in each bin), the fourth sensor (S-4) was located outside of barn, the fifth sensor (S-5) – in the main channel which supplies warmed-up air (Fig. 1).

During the calibration of the measuring system, a mechanical meter of the air flow was used (Fig. 2) which fixed the minimal air flow speed required for the functioning of sensors DS1923. To decelerate the air flow speed in the zone of sensors, smother fences were used. The meter Wile 66 was used (Fig. 3) to control the humidity of grain before its filling into the bins.

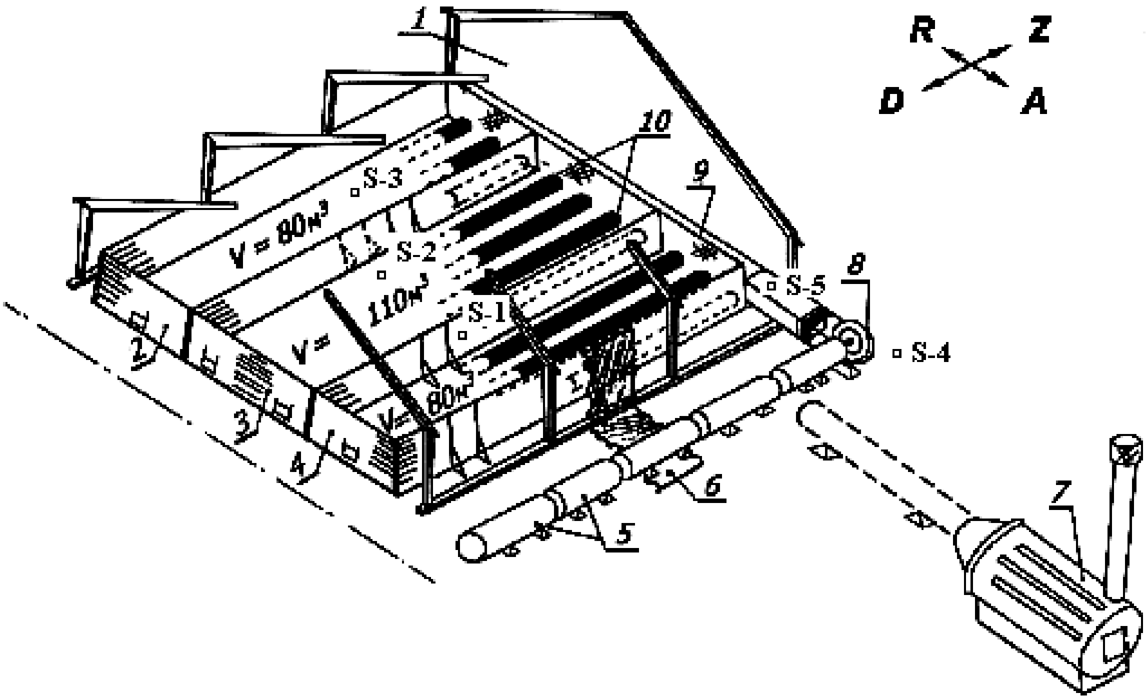

Fig. 1. **A scheme of an ecological grain drier-storage plant having ventilated bins provided with sensors:** 1 – the barn; 2 – 4 - ventilated grain drying-storage bins; 5 – air collectors; 6 – a solar energy absorption film; 7 – the heat generator (furnace) 40 kW; 8 – a radial fan HL 15; 9 - the main air channel; 10 – operating channels; □ S-1, □ S-2, □ S-3, □ S-4, □ S-5, □ S-6 – sensors DS1923

Fig. 2. **Air flow speed meter**

Fig. 3. **Grain humidity meter Wile 66**

Results and discussion

The conducted studies and practical experience showed that slow desiccation of grain and its storage in ventilated bins was preferable and efficient. The weather conditions in the last few years were not favourable for the grain to gain uniform ripeness. Therefore, the quality of the grain harvested by a combine harvester corresponds only to the quality of the forage grain, which has a lower price. Due to slow desiccation at low temperature (up to 30 °C) the grain becomes ripe, its quality grows and the grain obtains the properties of food grain (Table 1).

The results of two-year improvement of the wheat quality by its conditioning (cleaning, sorting and ecological drying) on the "Mazkalnini" farm are shown in Table 2.

Table 1

Quality requirements for wheat

Class of wheat	E[1]	A+	A	B	L
Protein	> 14 %	> 14 %	> 13.5 %	> 12.0 %	< 12.0 %
Zeleny	> 50	> 50	> 30	> 22	< 22
Gluten	> 27	> 27	> 24	> 23	< 23
Volume mass	> 780	> 780	> 760	> 740	< 740
Falling number	> 280	> 280	> 250	> 240	< 240

[1] For E class only wheat of certain special sorts as: Busard, Zentos, Fasan, Maxi can correspond.

Table 2

The results of two-year improvement of the wheat quality by its conditioning with ecological drying on the "Mazkalnini" farm

Designation of indices	Mass tons	Mass %	Price LVL t^{-1}	Sum LVL	Sum %
Year 2007					
Gathered with a harvester	248	100	65	16120	100
After conditioning	230	93	-	35950	223
incl.: E (ekstra) class	122.00	49	155	18910	-
A+ class	93.00	38	145	13489	-
A class	-	-	-	-	-
B class	-	-	-	-	-
L class	4	2	65	260	-
seed grain	11	4	300	3300	-
Year 2008					
Gathered with a harvester	276	100	55	15180	100
After conditioning	246	89		27906	184
incl.: E (ekstra) class	177.60	65	110	19536	-
A+ class	50.40	18	100	5040	-
A class	-	-	-	-	-
B class	-	-	-	-	-
L class	6	2	55	330	-
seed grain	12	4	250	3000	-

It follows from Table 2 that the food properties of wheat during its conditioning had improved considerably reaching the level of Extra and A+ classes, and the grain was sold at a much higher price. For example, in the years 2007 and 2008 the income from selling conditioned wheat on the "Mazkalnini" farm was twice higher than the income gained selling grain directly from the harvester.

The computerised system provided with sensors DS1923 allowed introduction of monitoring into the technological grain drying process ensuring its operative control thus obtaining high-quality dry grain with low energy consumption and expenses. Online monitoring of moisture and temperature in the grain storage facility prolonged the drying time by means of active ventilation. Owing to the information obtained from the digital temperature and humidity sensors, the drying period was extended by 15-25 % every day.

In the year 2008, the humidity of the harvested grain was within the range of 16…23 % (on the average – 19 %). The humidity of the dry grain fell to 13% (the basic humidity – 14 %). The total drying time was 380 hours. 4560 kWh of electric energy at the cost of 0.077 LVL $(kWh)^{-1}$ and 40 m^3 of firewood at the cost of 10 LVL m^{-3} were consumed for drying the entire quantity of the harvested grain (with 6 % evaporation of humidity), which made, in total, 750 LVL (1 LVL = 1.43 € ≈ 2 USD). Amortisation of the equipment (including the computerised system with sensors) constituted 255 LVL, the salaries for the service staff were 456 LVL. In total, the expenditure on grain conditioning, including the slow "soft" drying, made 1462 LVL. The cleaning and drying of the same quantity of grain at the "Latraps" firm cost 3600 LVL that is 2138 LVL more expensive.

Conclusions

1. The developed computerised system, provided with sensors DS1923, allowed the introduction of monitoring into the technological grain drying process–ensuring its operative control thus obtaining high-quality dry grain with low energy consumption and expenses.
2. Online monitoring of moisture and temperature in the grain storage facility prolonged the drying time by means of active ventilation. Owing to the information obtained from the digital temperature and humidity sensors, the drying period was extended by 15-25 % every day.
3. Due to slow desiccation at low temperature (up to 30 °C) the grain becomes ripe, its quality grows and the grain obtains the properties of food grain and it may be sold at a much higher price.
4. The use of computerised ventilated bins for drying and storing grain is purposeful in the organisational, as well as economical and ecological aspects. It facilitates the farmer to organise the harvesting process, to use favourable weather conditions to a full extent, to obtain a higher-quality product and sell it on more profitable terms. This increases the manoeuvrability of production, makes it less dependent on the weather conditions and the grain reception centres and raises the profitability of grain production.

References

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